

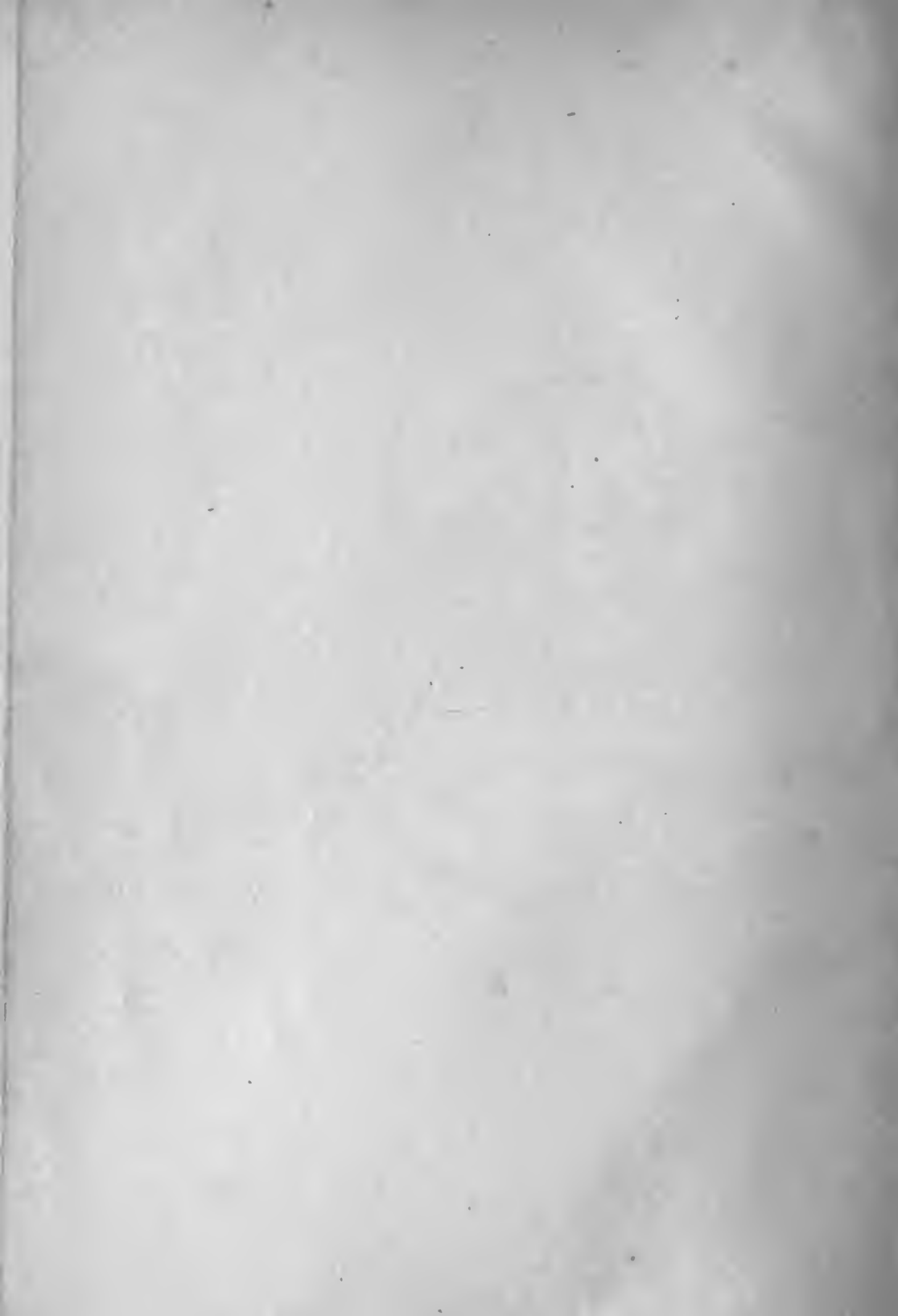
F
912
B-K8



Class F912

Book B7K8





/

615

A L A S K A B O U N D A R Y S U R V E Y

BY

OTTO JULIUS KOLTZ
"

FROM

POPULAR ASTRONOMY

MARCH APRIL 1896

F9.2
.B7K8

vanced our knowledge of them greatly during the last two years.

It is a natural question to ask why it is that all this detailed knowledge of the surface of Mars was not observed by others sooner, especially after its announcement by Schiaparelli. It could not be that his telescope was better than all others, for it was a small one. It could not be that his sharp and trained eye was so much superior to all others, that what he could see well and minutely describe should be wholly invisible to all other observers for a period of nine years after announcement. This question almost more than any other has interested astronomers very greatly of late, and induced thoughtful study of it as never before. The trial of mountain stations for observation, those in regions of quiet, clear air of lower altitude and those of broad high plateaus have all been made, to learn by actual use the best conditions for difficult telescopic work. The planet Mars has recently been in favorable position in regard to distance from the Earth for the study of surface markings, and the opportunity has been most diligently and persistently used by the aid of telescopes of all sizes and in all favorable latitudes for the sake of learning something new and helpful in making astronomical observations that would bring into use the highest powers of the modern telescope.

Those who desire the sources of best information in regard to what is now known about the planet Mars, and a delightful account of how astronomers have gained their knowledge should read two important books: one by Camille Flammarion, of Paris, published in 1892, and the other by Percival Lowell, of Boston, recently published by Houghton, Mifflin & Co. Flammarion's book was by far the most complete and comprehensive study of Mars that had appeared up to its date. It is indeed a scholarly compendium of what was known of the planet, involving much illustration and great pains-taking in gathering materials. On the other hand Mr. Lowell showed good judgment in not attempting to write another book on the same subject like that of Flammarion, but by the aid of a fine 18-inch refractor he has tried most industriously and effectively to widen the range of knowledge concerning a score of vitally interesting questions chiefly about the physical conditions that exist on the planet Mars. How well he has succeeded in this any thoughtful reader can judge for himself after a perusal of his book which is written in plain popular language, but crowded with an array of facts that are made to signify much that is new by the gifted and ready reasoning power which Mr. Lowell possesses as a writer, in a re-

markable degree. Later we wish to make a careful comparison of his views which are deemed new with those of others bearing on the question of Martian atmosphere, temperature, canals, water inundation, desert regions and other similar features which Mr. Lowell's book discusses.

ALASKA BOUNDARY SURVEY.

OTTO J. KLOTZ.

FOR POPULAR ASTRONOMY

The surveys that have been made during the past three years were not made with the object of defining the boundary line of southeastern Alaska, but for the purpose of gathering data so that the question of delimitation may be more intelligently discussed, prior to actual marking on the ground. The survey was carried on under a joint Commission, W. F. King being Her Majesty's Commissioner, and T. C. Mendenhall, now succeeded by Genl. W. W. Duffield, Superintendent of the Coast and Geodetic Survey, representing the United States.

In 1893 the U. S. Coast and Geodetic Survey had twelve officers in the field, of whom three had charge of parties, three were astronomers and the remaining six were attached to six Canadian survey parties. Canada had seven parties in the field and all engaged in topographic work. There was a Canadian representative, too, on each of the United States Stikine and Taku River parties. Furthermore each country had a vessel for intercommunication between the parties.

The area covered by the Canadian parties during this season included nearly all the territory adjoining the shore line from Burrough's Bay or the Unuk River which empties there, to the west side of Taku Inlet.

The United States parties were engaged in the survey of the Stikine and Taku Rivers and Taku Inlet; and in the determination of the latitude and longitude of the mouth of the Unuk, Wrangell, and the mouth of the Taku. Sitka served as base station for longitude, whence chronometers were carried fortnightly by the United States survey vessel to the three astronomical stations mentioned. In 1894 the operations were continued and extended, and on similar lines. The close of this season left little remaining to be done for the present. Canada had only one party in the field this year (1895), and its work was along the base of the Mt. St. Elias Alps.

Of the methods of work in the field I will only speak of those adopted by Canada.

Knowing beforehand the intensely mountainous character of the country under discussion, it was obvious—based on experience in the Rocky Mountains—that the most practical and cheapest method for a topographic survey was by means of the transit and camera. The idea of the application of the camera for topographic purposes is not new, but its practical application on a large scale is of recent date. Germany, France and Italy have done photographic work, but only the last named country has done any on an extensive scale. However, Canada has done considerably more, and has raised the art from its experimental stage to one of permanency, through the labors of her Surveyor General, E. Deville.

Without following photo-topography through its various stages of development in Canada, we will confine ourselves to a statement of the *modus operandi* of the Boundary Survey.

The greatest drawback to the progress of the work was the continuous saturated condition of the atmosphere showing itself either as rain, fog or fog banks, and clouds so that the area covered by survey in a season is not a fair estimate of what the parties could have accomplished under ordinary climatic conditions. Many a time did an early morning bode a fair day, when a start would be made from a seashore where camp was almost invariably pitched, for an ascent of perhaps five thousand feet, only to find after hours of scrambling through Devil's Club (*Fatsia horrida*), knee-deep moss, windfalls, alder brush on land slides; then emerging through timber line onto rock and snow and glaciers with their treacherous crevasses; skirting chasms and abysses, at times with only slender foot-hold to save from the yawning depths; again lying full length with arms extended on smooth, slippery glaciated rock and creeping along, onward—upwards to the goal, and when reached, oneself enveloped in a bank of clouds hovering around the peak and completely shutting out the world. Perhaps it will lift is the ardent hope. One waits, shivers. At times it snows to add to the discomfort, often misery. In vain, the day advances, the Sun is seeking its western home, and with faint heart the party has to begin the descent. It is made more quickly than the ascent but often with more danger, as the men indulge in the expeditious method of glissade—sliding on the ice or snow crest with the imminent danger of a crevasse or precipice. But camp, like the word home, has a magic and magnetic spell. Almost nothing save destruction stops the powerful attraction.

However disheartening such work is, success can only be accomplished by working until one does succeed. Hence many a mountain peak was climbed more than once, one in fact eight times. Success is good natured and immediately forgets all previous trials and tribulations. The season of 1893 did not give a dozen really good days for instrumental and photographic work.

A good view from a peak has been aptly described by

"What a scene of desolation
I saw from the mountain peak;
Crags, snowfields, glaciation,
Unutterable to speak."

The shore line of the northwestern part of the continent is very much indented by bays, inlets and fiords or canals. Adjoining the sea the vegetation is rank, and the luxuriant mosses and ferns give it a semi-tropical appearance. Timber line is reached at about 2,500 feet. The forest is almost exclusively coniferous.

Nearly the whole of the shore of the territory under consideration has been surveyed and charted by officers of the United States Navy, and this, in a measure, served as a base for the topographic work. However, each party measured, by means of steel tape, a base line at some known point on the shore, and from it expanded a triangulation over the area whose topography was to be delineated. It is scarcely necessary to state that for mountain work everything must be made as portable as possible, and instruments reduced to a minimum of weight.

The outfit of each party consisted of a Troughton & Simms 3-inch transit theodolite in a leather covered box and carried like a knapsack; an extension tripod; a camera, to be described more fully hereafter; several aneroids by Hughes; a sidereal chronometer; a field glass, and one or two box compasses; and each man was provided with the indispensable alpenstock. For transport each party was supplied with one Mackinac boat, which served its purpose admirably, and one or two Peterborough canoes, those marvelous water sprites that dance on rapids or on the ocean billows with a steadiness wonderful. I recollect one of our American friends thought them at least "cranky" looking and had some hesitation in getting into one of them, saying that for safety he ought to have his hair parted in the middle.

Both the horizontal and vertical circles of the transit read to minutes of arc. Angles were read in the usual way, *i. e.*, one set—circle right; the other—circle left. The sides of the triangles were mostly between six and ten miles, although distant peaks were tied by sides upwards of forty miles long, and St. Elias by

lines over sixty miles long. It may be stated right here that the photographs of these latter distances came out sharp and clear and flat, and were hence available for outline topographic purposes. At each station horizontal and vertical angles were read on all the principal peaks and points in the terrene. From the horizontal angles the triangulation or skeleton, upon which the topography is based, is obtained; and from the vertical angles the heights of such peaks, which are later checked by the photographs themselves. As some of the peaks occupied were isolated, sharp and well defined, signals or cairns were not placed at all the summit stations. The azimuth was controlled by solar observations when obtainable. Stellar observations were impracticable at mountain stations, although some were taken at sea shore.

As the camera is the characteristic instrument of the Canadian Survey, a somewhat detailed account of it will be given. As before intimated, the camera, in its present form, is the outcome of yearly experiments and experience since its first application by Canada in the Rocky Mountains in 1886.

The first distinctive feature about the camera is that it has no focusing adjustment, as all views taken are distant, the rays are practically parallel and converge at the same distance from the lens. The camera box is therefore very rigid, of well seasoned mahogany and brass bound. For use it is attached to a brass foot with levelling screws, and held by a stout screw, with milled head, passing through the middle of the foot, and into a brass block in the box. The foot itself fits onto the transit tripod, the latter serving for both instruments.

As it is essential that the camera be horizontal, it is provided with two levels in the form of a T, attachable to a brass grove on top of the box. In the middle of each side and directly in front of and close to the sensitive plate is fixed a narrow ($\frac{1}{8}$ ") brass comb. The four are consequently photographed on each view, and serve the purpose of readily drawing the horizon and principal lines on the photograph or enlarged print, for these are the lines of reference or axes of coördinates for interpreting the prints. Each camera is provided with six double holders, numbered and carrying a dozen glass plates, which are generally sufficient for a day's climb. The plates are $4\frac{3}{4} \times 6\frac{1}{2}$ ", isochromatic and made by Edwards, London. The plates before being put into the holders are marked in one corner with consecutive numbers, together with the initial of the chief of party, and a note is made of the corresponding number of the holder, so as to be able

to enter in the field book, when exposing, the number of the negative, its corresponding station and view. Each party was provided with a small black tent, lined with red, and a red light lantern for changing plates. The tent was just large enough to admit one, and was generally suspended from the ridge pole in one of the camp tents and overhanging the small camp table, so that the changing could be done with ease and comfort. There being really no night in midsummer in Alaska, it would scarcely be safe to change in an ordinary tent, even at midnight. The camera could also be set on end on the tripod. This was for the purpose of being able to photograph deep ravines or cañons where the vertical element exceeded the horizontal.

The lens or objective is a wide angle one by Dallmeyer, London. Between the two lenses forming the objective is inserted the diaphragm or stop. Of those supplied with each camera, the smallest one $\frac{1}{8}$ " is always used. The focal length of the lens is $5\frac{3}{8}$ ". The lens screws onto the detachable front piece of the camera, and when not in use is carried in a leather case. In screwing it in place it is always brought up to the mark cut on the collar so as to preserve a uniform distance from the sensitive plate.

(TO BE CONTINUED.)

NOTE.—For giving an idea of the country in which the work was carried on, and also of the result of photographing distant views the reproduction of photographs is given as frontispiece.

One of our grandest views is that of photographs covering parts of the vast complex of the Muir Glacier System.

On view No. 1 will be noticed the comb marks in the middle of the sides. The two straight lines joining the proper points on opposite combs constitute the axes of rectangular co-ordinates for measurements on the photograph. This view is taken from an elevation of 5913 ft. The station is situated between the two main branches of the Baird Glacier emptying into the northern part of Thomas Bay, Frederick Sound. The pointing of the camera is southeasterly, across the eastern branch and along one of its affluents onto the Devil's Thumb, (shown on left hand side) 9105 ft. high, and distant sixteen miles. Most of the other mountains shown are more distant, some over thirty miles.

Comparing this photograph with ones taken about Borrough's Bay—in general with those of the more southerly areas where the heights are mostly confined to heights of less than six thousand feet—a marked contrast is noted and that is, that mountains of less than the latter height are invariably rounded showing no sharp pinnacles or peaks, while those to the north, exceeding such height, have very angular and sharp crests. The former have been subject to glacial abrasion, the latter not, *i. e.*, not above say six thousand feet.

View No. 2 is from a station, altitude 4,881 ft., on the east side of Thomas Bay, and looking northeasterly, also showing the shaft of the Devil's Thumb. This station with the preceding one and the Devil's Thumb form approximately an equilateral triangle of 16-mile sides. It will thus be seen that these two views

The methods of work were described in detail with such account of the New Haven instrument as was necessary to show the nature of its operation. The diameter of the Earth's orbit is the base line for measurement of parallax and accordingly observations of the position of the star are taken at intervals of six months. The star is carefully located with reference to its fellows in the sky, four companion stars in four directions being selected for this comparison. The slight difference in position resulted from these measurements is the parallax, and from this may be determined the distance of the star from us.

Of like nature is the problem of the distance of the Sun, and upon this Dr. Elkin has been at work with results which at first were received with caution on account of their apparent smallness but which have since been supported by new determinations in other ways. The close relationships which have been proven between the elements which compose our solar system are such that the exact determination of the distance of any one planet will afford a means of computing all the other dimensions and distances. It was therefore suggested that the observations of some of the asteroids might be of value, and accordingly Dr. Elkin made a series of measures of Sappho and Victoria, with a result as above stated.

In addition of these matters attention has been given at New Haven to the triangulation of some seventy stars in the Pleiades, each of which was independently measured for position at intervals, standard stars outside of the group having been selected for the purpose.

"These different accomplishments," said Dr. Chandler in finishing, "constitute a record of faithful, zealous, and vigorous prosecution of astronomy in its very highest plane, and the presence of such a man as Dr. Elkin in our country gives standing and credit to American astronomy."

ALASKA BOUNDARY SURVEY.*

OTTO J. KLOTZ.

FOR POPULAR ASTRONOMY.

The second distinctive and most important feature of the camera is the attachment of a plano-glass orange screen to the lens. It is screwed to the back of the objective. It is obvious

* Continued from page 353.

that it is desirable to have on the negative not only what we can see, and especially is this true of the distance, but also that distinct and not blurred. Now the negative or sensitive plate, which is analogous to the retina of the eye, is however not sensitive in the same measure to the visual rays as the retina. Visual rays are at the red end of the spectrum and photographic, or actinic at the blue end. A ray of light from the Sun before reaching us suffers partial absorption by the atmosphere which in turn reflects and diffuses light. Hence a reflected ray from a distant point enters the camera in a depleted state, suffering from loss of vigor. However it could still do effective work if it did not meet with the antagonizing energy of the rays—less luminous but more actinic—reflected by the atmosphere, so that the weak imprint of the former is almost completely annihilated by the action of the latter. To overcome the difficulty, or at least to tend towards attaining our end, recourse is had to isochromatic plates and the orange screen above mentioned. The emulsion of these plates is colored for intensifying the action of the yellow rays which reach it from the distant point, and the orange screen for absorbing or cutting off the blue rays entering the camera from the atmosphere. Photographically speaking, we try by means of the orange screen to create a vacuum between us and the distant view to be photographed so that the rays from there, filtered as they are already may have some chance of doing satisfactory work. The blue haze is the enemy—and it is drowned in the artificial yellow sea. For the proper development of the negatives some light is necessary and to which the plate must be insensitive. The isochromatic plates used were made insensitive to red, and hence were developed under red light. The photograph of a red object would therefore print black, that is on the negative would appear blank. The sensitiveness of the plates was confined almost wholly to the yellow part of the spectrum. We are therefore from the conditions surrounding us, obliged in applying photography to topographical purposes, to utilize the yellow rays and cut off the more powerful (photographically) blue rays.

Without the insertion of this screen, much of the work accomplished with the camera would have been impossible, hence its great value.

In such an essentially humid atmosphere as obtains in southeastern Alaska, extra provision had to be made to keep the plates dry, and also for the event of casualties on the water. Hence tin boxes were provided, each holding two dozen glass

plates. These boxes were water tight and had air chambers, so that when containing the plates they would float.

The field operations with the camera are very simple, yet require discretion, and the value of the expert topographer comes into play. Having arrived at a summit station, the transit or camera is first set up, depending on atmospheric conditions. A sketch is made of the horizon, and of the broad features, noting specially peaks or other points read on. As the lens takes in sixty degrees, seven plates will take in the whole horizon and allow a lap for each one, so as to have one or more points common to two photographs for orienting one view from another. As there is no ground glass for seeing the field covered, two diverging lines are cut or scratched on the top of the camera indicating the angle of the lens. Sighting along these one readily sees the limits of the view and thereby can give the proper consecutive pointings. Every station does not require a complete circuit of the horizon. It also happens that the photographs from a peak do not show sufficient of detail of valleys, being hidden by the configuration of the mountain, whereas, by going a short distance—a hundred or so feet from the summit—the desired view is obtained. This is done and the direction and distance of the new position of the camera from the station noted. In plotting on a $\frac{1}{80000}$ scale—that of the original office sheets—such camera station may often be taken as co-incident with the triangulation station.

As the plates are exposed a record is made of the numbers of the plate, the pointing of the camera and the view taken. The time of exposure varies, of course, with the position of the Sun, the state of the atmosphere and the nature of the object. As an aid in estimating the quality of the light each surveyor carried what may be termed an actinometer. It was the size of a large locket and contained a continuous strip of sensitive paper. By pulling out a short piece and noting the time it took to assume a certain tint a fair estimate of the quality of the light would be obtained, and the exposure made accordingly. The exposure ranged from 6 to 40 seconds. It is satisfactory to be able to state that of the 250 dozen plates exposed not a single one proved to be worthless. Some were exposed (from necessity) even when it was raining.

Each party was supplied with several aneroids, one of which was left at camp for continuous reading. A mercurial, Greene, barometer was carried on board the Survey steamer, and with it the aneroids were compared. The aneroids furnished a ready

means of obtaining the approximate height of the mountains climbed. Some of the parties carried thermometers too in their ascents for taking the temperature of the air so that the aneroid reading could be more accurately reduced. The final altitudes of all points, however, rest on the trigonometric determinations and those obtained from the photographs based thereon. From a large number of readings of the aneroid which were comparable with trigonometric heights, it was found that by carefully reading the barometer at ascent and descent, and noting the temperature of the air by a good thermometer (not attached to the aneroid) that the mean will give a fair value say within two per cent of the difference of height of the summit and base or sea. This applies to mountains upwards of five thousand feet in height.

Without going into the details of the office work some of the salient points connected therewith may be mentioned. From the negatives enlargements are made to twice the linear measure, *i. e.* to four times the surface, on bromide paper. The focal length and position of the horizon and principal lines with reference to the comb marks are specially determined by taking a photograph of a large building on which three or more horizontal and vertical angles each are read. Any field photograph in which the azimuth and elevation or depression of a number of points have been taken furnishes the necessary data too, in fact thereby we have a means of checking for contraction or expansion of the paper of the print, as the focal length and horizon line for any camera are constant. The plotting is done on a scale of one in eighty thousand. First the meridians and parallels are projected, then the triangulation is plotted.

Evidently every photograph by itself gives the relative azimuth of every point in it from the pointing of the camera, *i. e.*, from the prolongation of the optical axis of the lens. So that if we measure on the print from the principal line (a vertical approximately in the centre of the view) to the right or left to any point the distance will express the tangent of its azimuth in terms of the focal length as unity. In utilizing the photographs, however, we have nothing to do with angles, but only with their linear measure, and these are all referred to the focal length as constant. If now, from the triangulation, we know the absolute azimuth of one point shown in the print, then we can lay off on the plan the relative azimuth of such point and thereby obtain the pointing of the camera. This now being known, the absolute direction of any point in the photograph immediately fol-

lows. Hence by means of the triangulation lines the photographs are oriented. From what has been just said it follows that a view containing no triangulation point may be oriented, provided it joins and laps one that has been oriented. Obviously for every point that can be recognized as identical on two views from different stations we have the direction from each station, and therefore know its absolute position,—being at the intersection of the two directions. As many points as can thus be recognized, just so many points can be plotted, and their distances known from the station.

In this manner we exhaust all desirable common points on the prints and transfer them to the plan. This eliminates the horizontal element of our perspective; we have next to deal with the vertical element, the one that expresses the topography.

Just as the principal line serves to measure the relative azimuth of any point, so the horizon line, which is drawn on the print between the lateral comb marks, serves to determine the elevation or depression of any point above or below the level of the camera.

Remembering that we now know the position and distance of the point whose height we wish to establish, the simple geometrical relation of similar triangles which subsists between focal length, absolute distance of point from station, and linear measure on print of point above or below horizon line, immediately gives us our fourth term in the proportion, *i. e.*, the linear measure expressive of the elevation of the point, and this measure is converted into feet by applying the ratio on which the map is constructed, that is, the scale. For the purpose of facilitating the graphical solution of similar right angled triangles, a triangular scale printed on card board 11 inches by 27 inches is used. The triangular scale is a large right angled triangle, subdivided by equidistant perpendiculars on the base and by radiating lines from the acute angle. To each point thus determined is written its height above the sea. When a terrene is filled with a sufficient number of established points, the contour lines, 250 feet apart, are drawn. This requires skill, for, with photograph in hand, the expert topographer sketches in details not indicated by the plotted points.

Points, as the shore line of lakes, islands and rivers, lying the same horizontal plane are readily plotted from a single photograph taken from an elevation of known height. The altitude must be sufficiently great so that the angle of depression is not too small. From an elevation of 3,000 feet above a horizontal

plane one can plot without difficulty points on it distant fully three miles.

In its broad outlines the plotting of photographs is nothing more than a continual graphical solution of right angled triangles.

We have taken some 3,000 photographs, and have covered, approximately, 14,000 square miles, with our photographic work.

The photo-topographic work, although perfection is not claimed for it, will undoubtedly displace the older methods of survey for highly mountainous areas, for its superiority over them has now been permanently established.

View No. 3 is from a station, altitude 4,319 ft., on the west side of the northern part of Thomas Bay and looking easterly across the Baird Glacier, showing its terminal, which almost reaches the sea—shown on the right hand. The view well illustrates the "flaw" of a glacier, which shows (the ice being a brittle and not a viscous mass) all the characteristics of the behavior of water, such as, the greatest velocity towards the center, the thread, eddies and falls.

From photographs taken at intervals covering several months and from the same stations on the fluvio-glacial deposit lying between the ice front and the sea I determined the rate of motion of the front of this glacier to be about one foot per day during the period of observation. It is believed that this is the first application of the camera for determining the rate of motion of glaciers.

View No. 4, shows that all in Alaska is not ice and snow and rock, but that along the sea shore the vegetation is rank; ferns, brakes, mosses, the Devil's club and other forms vying with each other in their luxuriant growth for supremacy. The particular locality represented is in the south side and near the entrance of Bradfield Canal. Other illustrations explain themselves.

THE VARIABLE STAR 8598 U PEGASI.

PAUL S. VENDELL.

FOR POPULAR ASTRONOMY.

One of the most interesting cases of variability which have recently been discovered is that of U Pegasi, of which a short notice was published in the *POPULAR ASTRONOMY* for December, 1895, by Mr. John A. Parkhurst.

In September, 1894, in the course of a correspondence with Dr. Chandler relating to certain suspected variables, I received an intimation from him that he strongly suspected that he had found a variable of the Algol-type, the second found by him during that season (the first being Z Herculis).

His next letter, dated Sept. 23, contained the means of identifying the star, and the suggestion that its period might possibly be about 2.06 days.

PLATE XIV.
ALASKA BOUNDARY SURVEY.



NO. 3. THE BAIRD GLACIER.

Reproduction of Photograph by the Canadian Commission Officers. See page 400.



NO. 4. AT SEA LEVEL.

Reproduction of Photograph by the Canadian Commission Officers. See page 400.

—
y

g

—

—

ot

f

r-

ag

v

d

be

:

:

:

—

t

h

f

PLATE XV.
ALASKAN BOUNDARY SURVEY.



NO. 5. IN FREDERICK SOUND.
Reproduction of Photograph by the Canadian Commission Officers.



NO. 6. BRADFIELD CANAL.
Reproduction of Photograph by the Canadian Commission Officers.



PLATE XVI.

THE ALASKA BOUNDARY SURVEY.



NO. 7. THE DEVIL'S SLIDE. LYNN CANAL.

Reproduction of Photograph by the Canadian Commission Officers.



PARLIAMENT BUILDING.—OTTAWA.

Reproduction of Photograph by the Canadian Commission Officers.



HE STRETCHETH OUT THE NORTH OVER THE EMPTY PLACE, AND HANGETH THE EARTH ON NOTHING

March 1896

CONTENTS

Alaskan Boundary Survey. Plate XI.	
The Discovery of an Unseen Body in the Stellar System, F 70 Ophiuchi. (Plate XII). <i>Eric Doolittle</i>	329
The Spectroscope in the Study of Variable Stars. <i>Taylor Reed</i>	333
A Method of Measuring the Distances, Dimensions and Masses of Binary Systems by the Use of the Spectroscope. <i>F. R. Moulton</i>	337
The Photography of Planetoids by Professor Max Wolf. (Abstract). <i>Dr. E. S. Holden</i>	343
The Planet Mars. <i>W. W. Payne</i>	345
Alaskan Boundary Survey. <i>Otto J. Klotz</i>	348
The Graphic Construction of Eclipses and Occultations. III. Occultations. (Illustrated). <i>Wm. J. Rigge, S. J.</i>	353
New Photographic Discovery.—The Solar Corona Photographed in Daylight. Chief Characteristic of the Corona. <i>D. E. Packer</i>	361
The Lunar Ephemeris. <i>Dr. J. Morrison</i>	362
The Planets and the Constellations for February. <i>H. C. Wilson</i>	370
Practical Suggestions.....	377
General Notes.....	379

EDITORS:

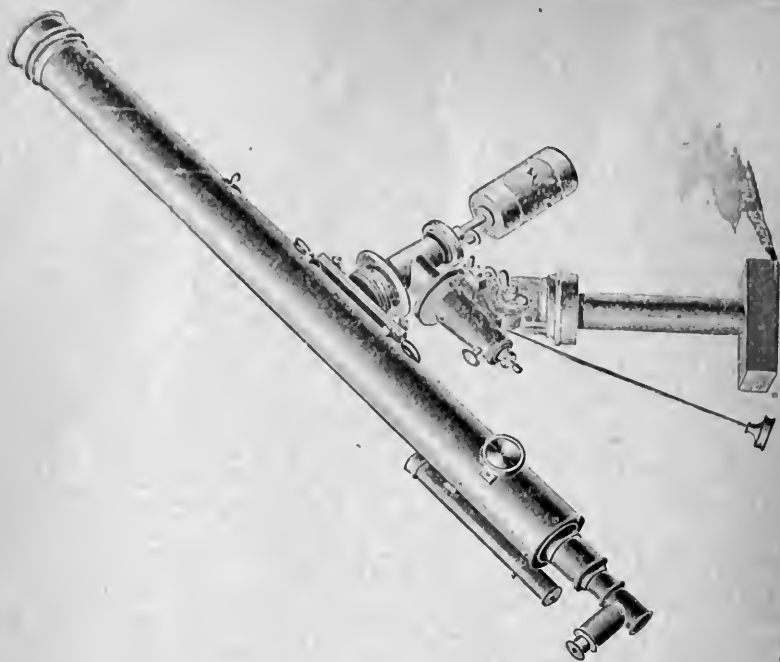
WILLIAM W. PAYNE,

CHARLOTTE R. WILLARD,

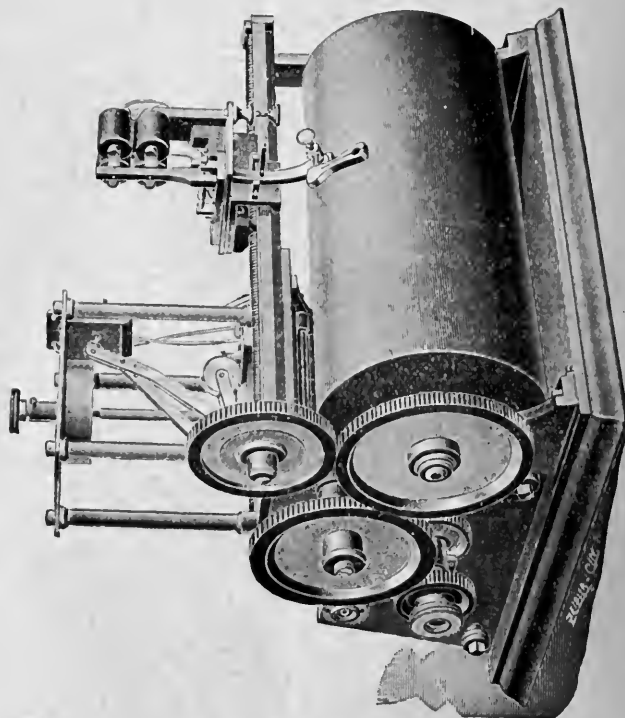
(Abroad for the year.)

GOODSELL OBSERVATORY OF CARLETON COLLEGE,

NORTHBELD, MINNESOTA, U. S. A.



Our Latest Pattern Plain Mounting for 2, 3, 4, 5-
in Telescopes. With or without driving clock.
Send for descriptive Circular.



OUR LATEST CHRONOGRAPH.
Everything in the line of Astronomical Instruments and all work
warranted. Send for circulars.

POOLE BROTHERS' CELESTIAL PLANISPHERE

A MOVABLE CHART OF THE HEAVENS.

Designed to show the Student the places of the Constellations at any given moment.

For the use of Observers, the Publishers have for sale Star Charts, being SPECIAL SHEETS of the PLANISPHERE printed on a suitable paper, so that the Student may make and keep a Record of any Celestial Phenomena of Special Interest, such as the Paths of Planets, Comets, Shooting Stars, etc.

POOLE BROTHERS' CELESTIAL HANDBOOK

CONCISE AND ACCURATE.

Companion to the Celestial Planisphere and Explanatory of its uses, besides other desirable Astronomical Information for both the Amateur and the Advanced Student.

It is difficult to imagine how astronomy could be studied under more favorable auspices than with this Planisphere and the very elegantly illustrated descriptive Handbook accompanying it.—Scientific American, Feb. 18th, 1893.

THE MOON

A NEW AND COMPLETE MAP OF OUR SATELLITE.

Compiled by Jules A. Colas; size $24\frac{1}{2} \times 29$ inches; diameter of Lunar disc $20\frac{1}{4}$ inches. Printed with blue background, representing the color of the sky in full moonlight, the disc being colored to represent well the seas, plateaus, mountains, craters and streaks as they appear in the telescope.

Accompanying the map is a full Index Pamphlet of twenty-four pages, with notes by Prof. W. W. Payne.

For Descriptive Circulars and other information, address

POOLE BROTHERS,

316 Dearborn Street, CHICAGO, ILL.

WILLIAM WESLEY & SON,
AGENTS,

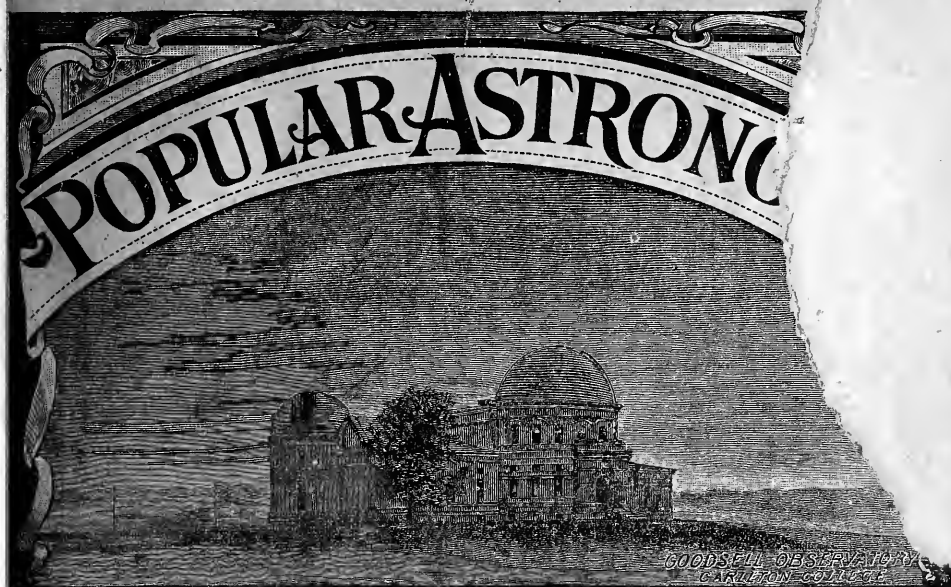
28 Essex Street, Strand, London, Eng.



Equatorial Telescopes

We have made Equatorial Telescopes of the largest size and have also in process of construction a line of smaller sizes for Educational Institutions and Private Observatories.

WARNER & SWASEY,
CLEVELAND, OHIO, U. S. A.



HE STRETCHETH OUT THE NORTH OVER THE EMPTY PLACE AND HANGETH THE EARTH ON NOTHING

April 1896

CONTENTS

Frontispiece, The Canals of Mars. Plate XIII	
The Planet Mars. W. W. Payne.....	385
The Spectrum of Mira (o Ceti). (Illustrated). H. C. Wilson.....	390
Astronomical Work of Dr. W. L. Elkin. S. C. Chandler.....	392
Alaska Boundary Survey. Plates XIV, XV, XVI. Otto J. Klotz.....	395
The Variable Star 8598, U Pegasi. (with Chart). Paul S. Yendell.....	400
Observations of Short Period Variable Stars. W. E. Sperra.....	404
Galileo's Work on Saturn's Rings.—A Historical Correction. E. A. Partridge and H. C. Whitaker.....	408
The Graphic Construction of Eclipses and Occultations IV Occultations of Clusters. (Illustrated). Wm. F. Rigge, S. J.....	414
The Planets and the Constellations for April with Chart. H. C. Wilson.....	425
Comet Notes.....	432
Practical Suggestions.....	437
General Notes.....	437
Book Notices.....	440

EDITORS:

WILLIAM W. PAYNE,

CHARLOTTE R. WILLARD,

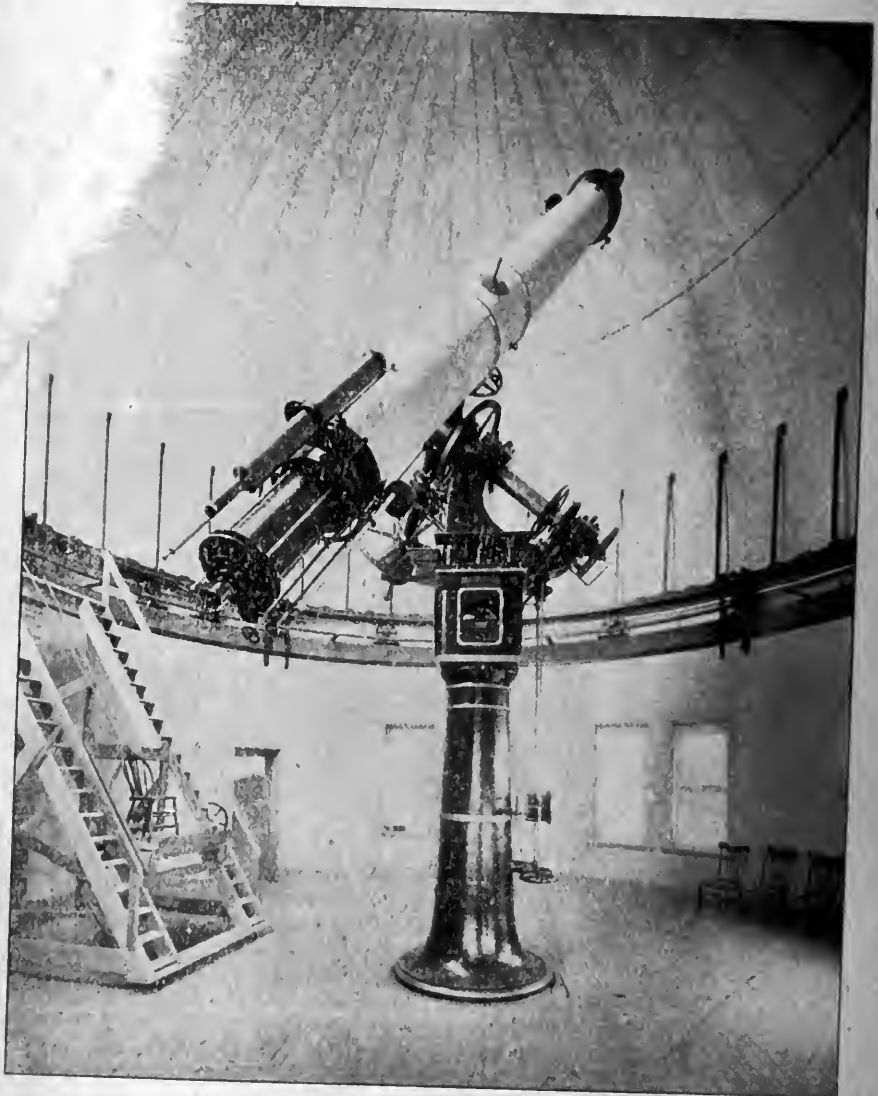
(Abroad for the year.)

GOODSELL OBSERVATORY OF CARLETON COLLEGE,

NORTHEFIELD, MINNESOTA, U. S. A.

Popular Astronomy.

GEO. N. SAEGMÜLLER,
WASHINGTON, D. C.



— Maker of — **TELESCOPES**

MOUNTED EQUATORIALLY OR PLAIN,

Equinoxes and Days of the Year.

Popular Astronomy.

POOLE BROTHERS' CELESTIAL PLANISPHERE

A MOVABLE CHART OF THE HEAVENS.

Designed to show the Student the places of the Constellations at any given moment.

For the use of Observers, the Publishers have for sale Star Charts, being SPECIAL SHEETS of the PLANISPHERE printed on a suitable paper, so that the Student may make and keep a Record of any Celestial Phenomena of Special Interest, such as the Paths of Planets, Comets, Shooting Stars, etc.

POOLE BROTHERS' CELESTIAL HANDBOOK

CONCISE AND ACCURATE.

Companion to the Celestial Planisphere and Explanatory of its uses, besides other desirable Astronomical Information for both the Amateur and the Advanced Student.

It is difficult to imagine how astronomy could be studied under more favorable auspices than with this Planisphere and the very elegantly illustrated descriptive Handbook accompanying it.—Scientific American, Feb. 18th, 1893.

THE MOON

A NEW AND COMPLETE MAP OF OUR SATELLITE.

Compiled by Jules A. Colas; size $24\frac{1}{2} \times 29$ inches; diameter of Lunar disc $20\frac{1}{4}$ inches. Printed with blue background, representing the color of the sky in full moonlight, the disc being colored to represent well the seas, plateaus, mountains, craters and streaks as they appear in the telescope.

Accompanying the map is a full Index Pamphlet of twenty-four pages, with notes by Prof. W. W. Payne.

For Descriptive Circulars and other information, address

POOLE BROTHERS,

316 Dearborn Street, CHICAGO, ILL.

WILLIAM WESLEY & SON,
AGENTS,

28 Essex Street, Strand, London, Eng.



Equatorial Telescopes

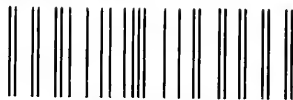
We have made Equatorial Telescopes of the largest size and have also in process of construction a line of smaller sizes for Educational Institutions and Private Observatories.

WARNER & SWASEY,
CLEVELAND, OHIO, U. S. A.





LIBRARY OF CONGRESS



0 014 432 070 0